

# Respirator and Surgical Mask Protection from Cough Aerosols

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## Background

Few studies have been done to quantify the incremental impact of personal protective equipment (PPE) such as N95 filtering facepiece respirators (FFR) and surgical masks on aerosol transmission of viruses like influenza.

In healthcare settings during periods of respiratory infection activity, Center for Disease Control (CDC) recommends that surgical masks be offered to patients who have respiratory infection symptoms.

CDC also recommends that a surgical mask be worn by healthcare personnel in close contact (within 3 feet) of patients with symptoms of respiratory infection and that healthcare workers (HCW) protect themselves from diseases spread through airborne transmission by wearing a fit-tested respirator. The World Health Organization (WHO) recommends surgical masks be worn where airborne infection is possible.

## Project Objectives

- Simulate exposure of a HCW to aerosol from coughing patients
- Demonstrate how aerosols spread in typical healthcare setting
- Measure how well surgical masks and disposable FFR protect HCW from aerosols produced by a coughing patient
- Use results to model of exposure to infectious aerosols

## Methods

The system, contained in a room-sized environmental chamber, has 3 main parts: (1) a coughing mannequin that discharges an aerosol-laden cough; (2) a second mannequin (called the breathing mannequin) that is connected to a breathing machine to simulate respiration and can be fitted with PPE; and (3) aerosol particle counters to measure the particle concentrations in the coughing and breathing systems and at different locations throughout the room.

The efficacy of surgical masks and respirators versus no mask was evaluated along with the influence of parameters including protection factor, breathing rate, relative position, and cough frequency.

- Test aerosol consists of 2% potassium chloride or FluMist and 0.9% saline, aerosolized with a Collison spray nebulizer
- Test aerosol is “coughed” from a mannequin, simulating a patient
- A second mannequin “breathes” ambient air, simulating a HCW
- Aerosol inhaled by second mannequin is either counted (for potassium chloride) or size-fractionated, collected and analyzed using real-time PCR (for FluMist).

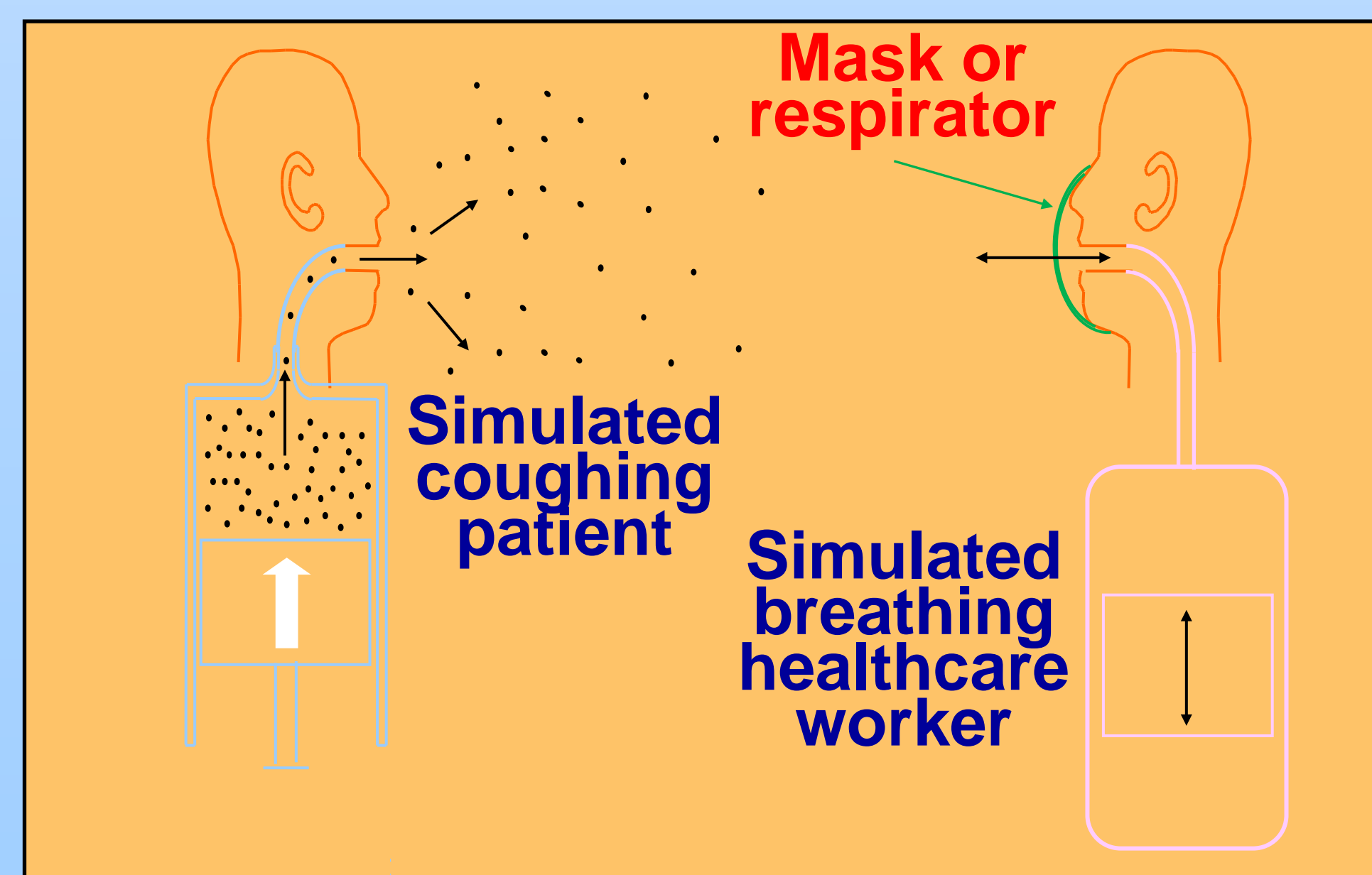


Figure 1. Simulation of healthcare worker and patient in examination room

- Simulated exam room is 9 ft x 9 ft x 8 ft tall
- Coughing and breathing mannequins can be positioned throughout room with up to 2 meter separation
- Room ventilation can be controlled
- Computational fluid dynamics model being created to understand spread of infectious aerosols and potential exposure

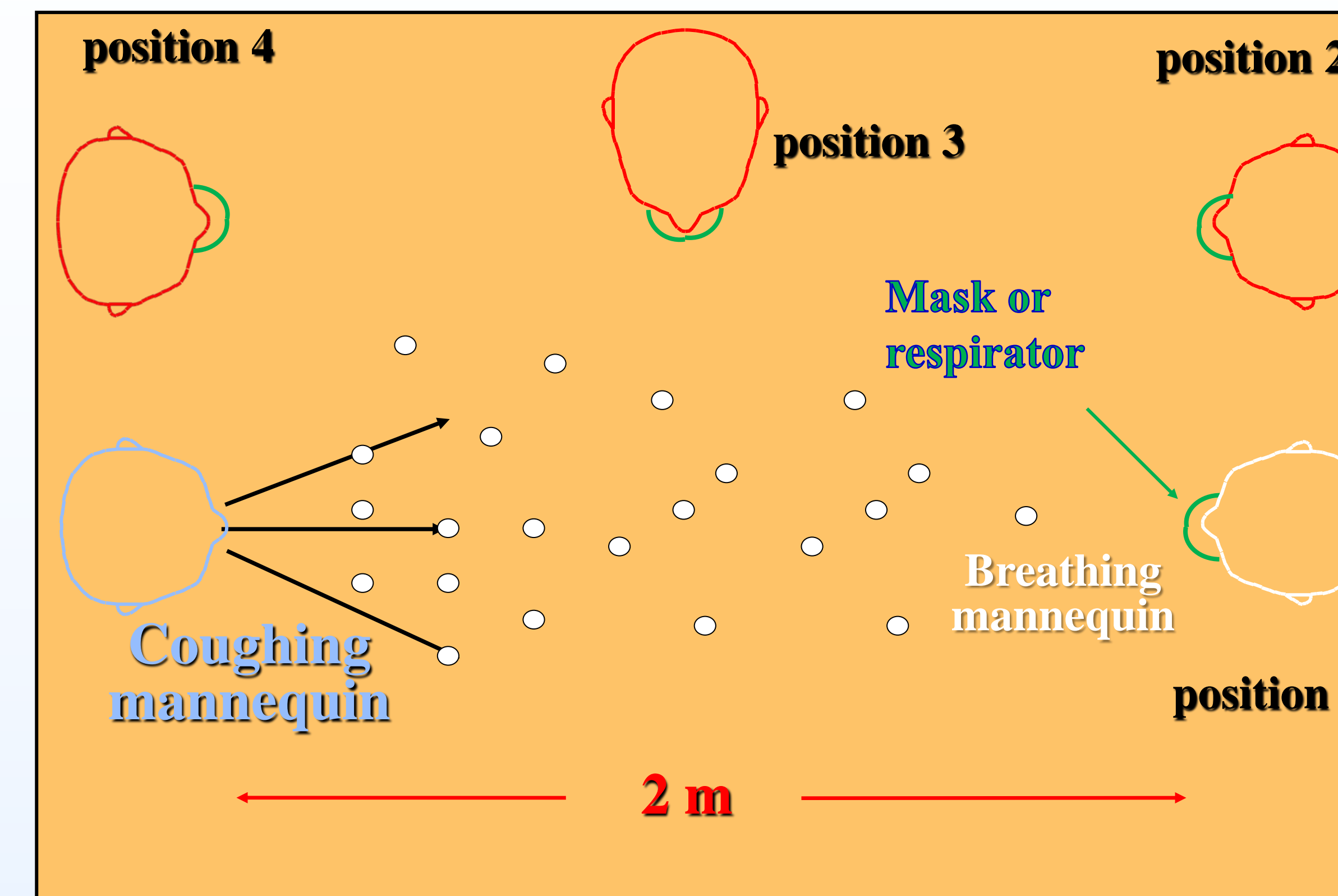


Figure 2. Top view of examination room simulation layout

## Results

- The aerosol coughed by patient reaches HCW in position 1 in seconds, positions 2 and 3, in less than 1 minute. (Figure 3)
- In about 5 minutes the aerosol spreads throughout the room including position 4. (Figure 3)
- Surgical mask admitted ~20% of particles (Figures 4 and 5)
- N95 blocked virtually all particles (Figures 4 and 5)

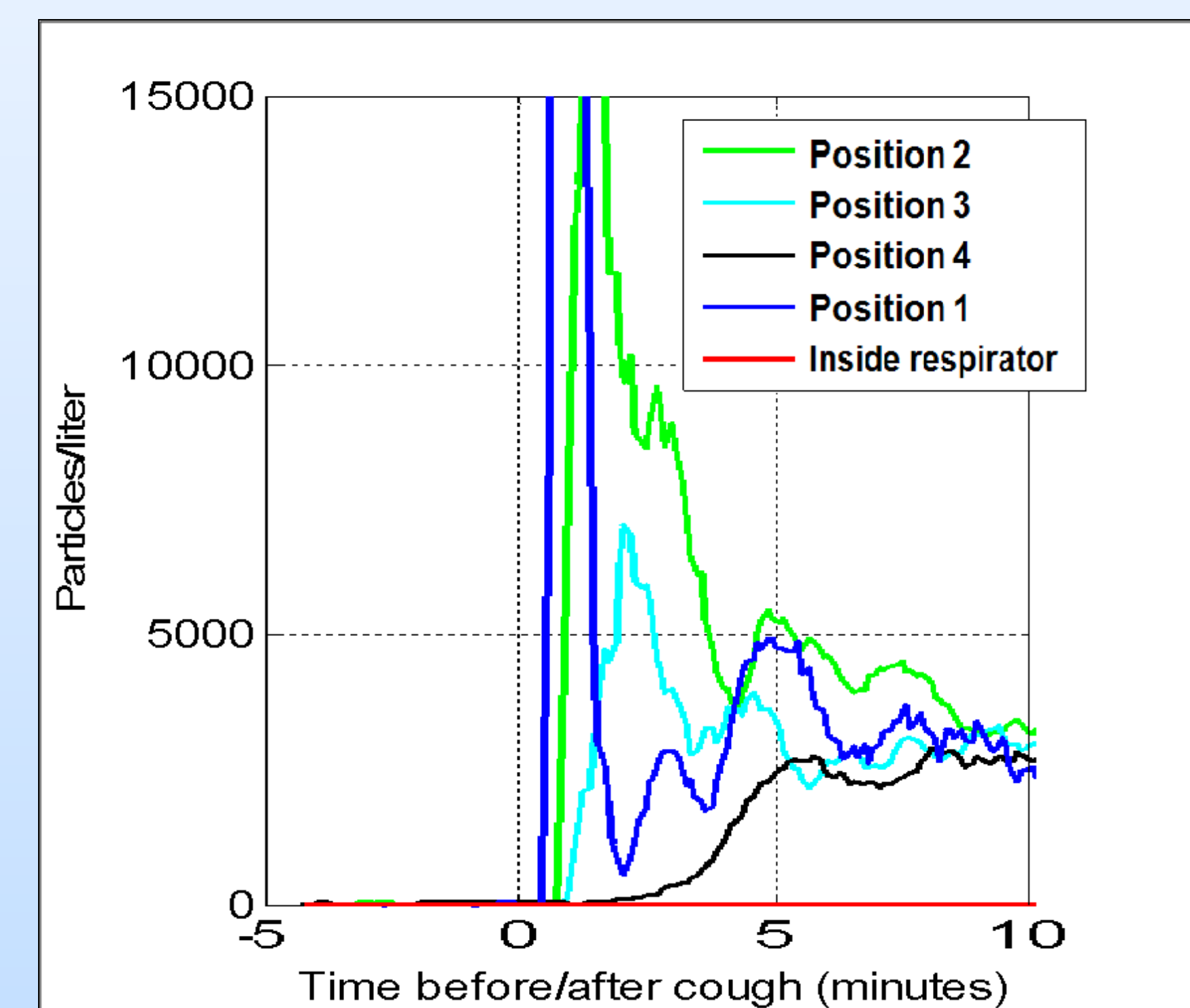


Figure 3. Spread of particles in room after cough

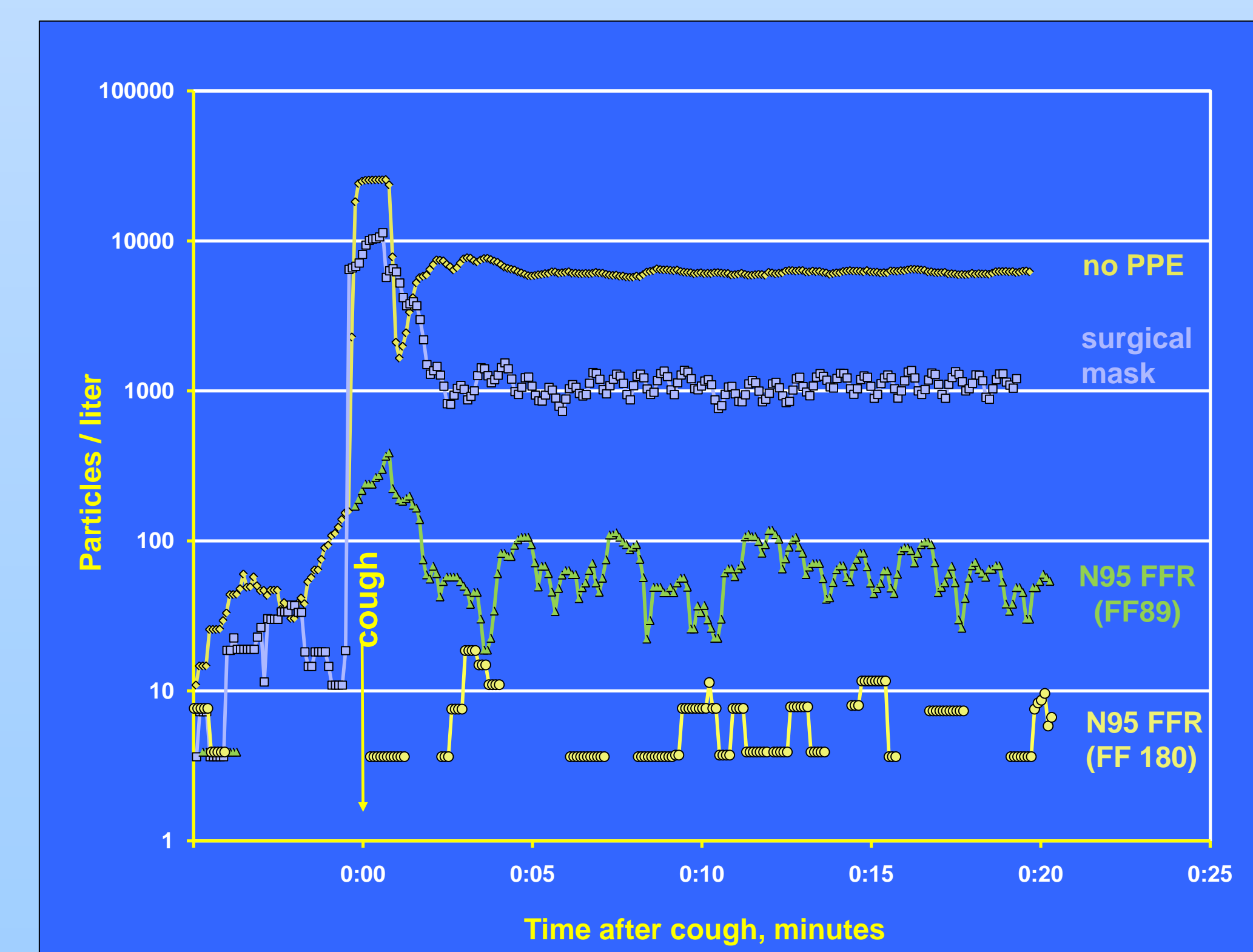


Figure 4. Particles inhaled with no device, surgical mask & N95 respirator

Overall penetration (Ci/Co averaged over the entire exposure) correlates strongly with the initial fit factor measured with a PortaCount just before the experiment.

Values for all surgical masks and N95 FFR samples run at position 1 and 32 lpm shown in the graph.

Surgical mask values are plotted in red, respirator values are in blue and green.

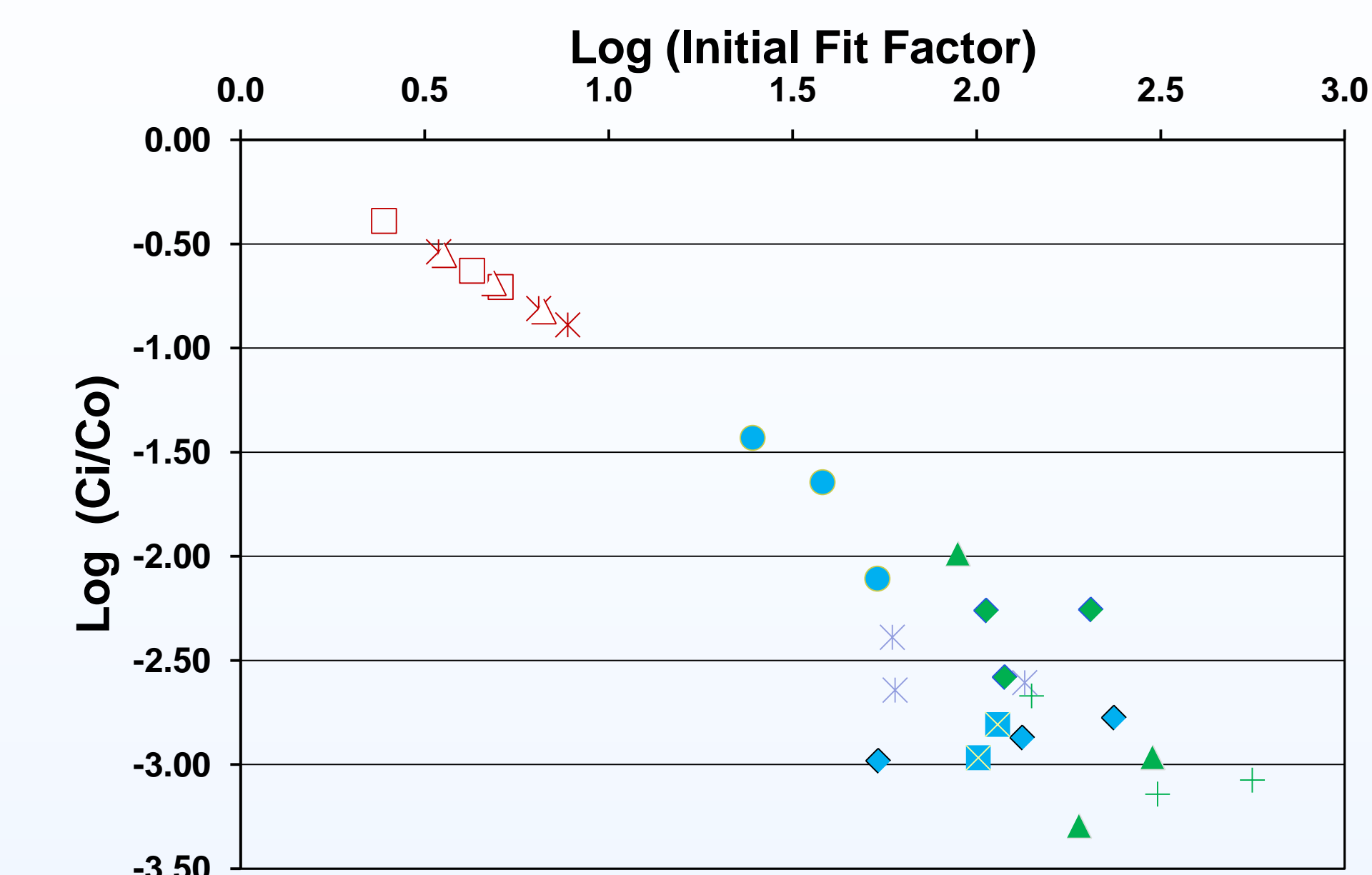


Figure 5. Overall Penetration versus Fit Factor for Respirators and Surgical Masks

## Conclusions

Preliminary results show that the aerosol exposure is highest with no PPE, followed by surgical masks, and the least exposure seen with N95 FFR.

With N95 FFR the magnitude of exposure also depended on the protection factor. These differences are seen regardless of breathing rate and the relative position of the mannequins.

Our results provide a better understanding of the efficacy of surgical masks and FFR when exposed to aerosols generated by a cough.

Results will enable NIOSH to provide research-based recommendations for effective respiratory protection strategies with surgical masks and FFR in healthcare settings.

## Findings

- Determination of the viral particle filtration performance of masks and respirators found significant differences among type (surgical mask or N95 respirator) and individual samples (make and model)
- Evidence of the degree of increased protection (reduction in viral particle penetration) that different masks and respirators provide as compared to wearing no mask or respirator
- The degree of correlation of filtration performance (from initial characterization) for each mask and respirator with the viral particle filtration performance establish a greater understanding of the efficacy of surgical masks and FFR when exposed to aerosols generated by a cough simulator
- Results add data to enable NIOSH to provide research-based recommendations for effective respiratory protection strategies for surgical masks and FFR in healthcare settings

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